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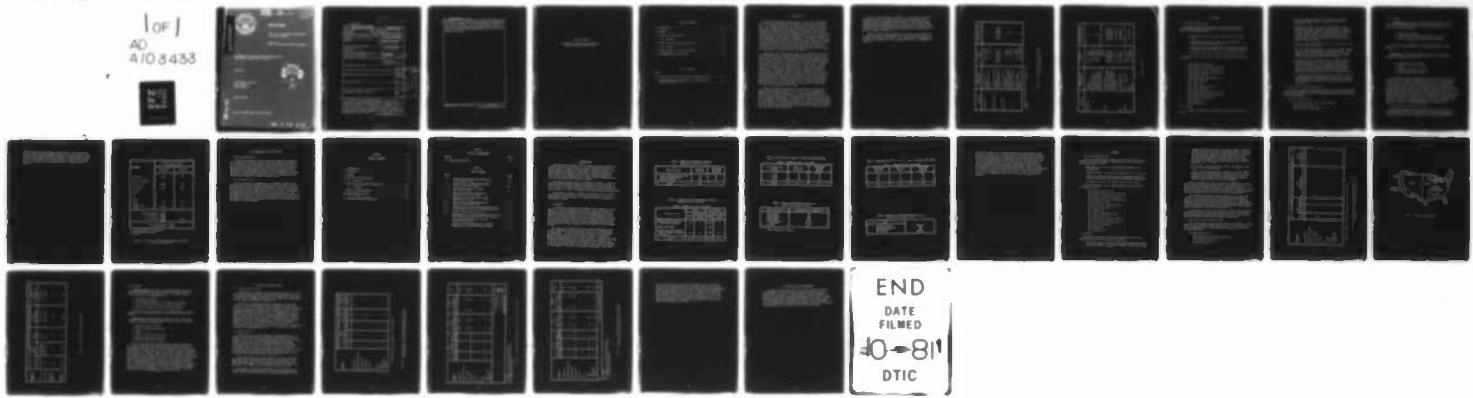
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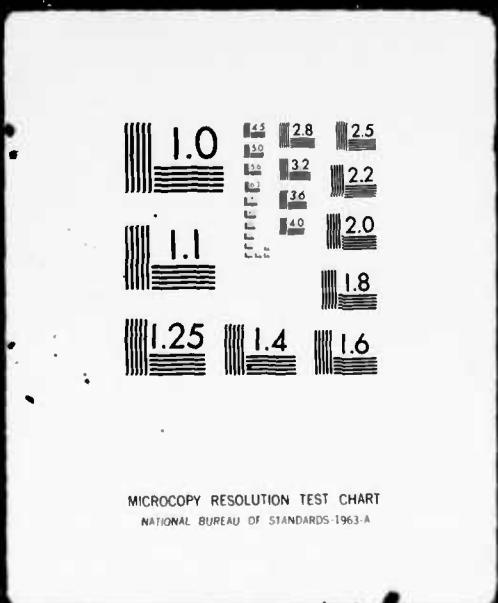
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NAVAL CIVIL ENGINEERING LABORATORY
Port Hueneme, California

Sponsored by
NAVAL FACILITIES ENGINEERING COMMAND

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ASSESSMENT OF ALTERNATIVES FOR UPGRADING NAVY
SOLID WASTE DISPOSAL SITES - VOLUME 3

August 1981

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An Investigation Conducted by
JRB Associates, Inc.
McLean, Virginia

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technological concepts that represent upgrading techniques, and (3) to identify research priorities concerning the technology for solid waste disposal. This document consists of three volumes. This volume (3) presents the general observations and findings of the study and projected impact of the Federal regulations on the Navy.

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EXECUTIVE SUMMARY

ASSESSMENT OF ALTERNATIVES FOR UPGRADING
NAVY SOLID WASTE DISPOSAL SITES

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1.0 INTRODUCTION

The Civil Engineering Laboratory (CEL), as part of the NAVFAC Solid Waste R&D Program, performed an assessment of alternatives for upgrading Navy solid waste disposal sites. The purpose of this effort was three fold: (1) to determine the extent the Navy may have to modify its current solid waste disposal practices to enable compliance with Section 4004 of the Resource Conservation and Recovery Act; (2) to define technological concepts that represent effective upgrading techniques; and (3) to identify research priorities concerning the technologies for solid waste disposal that are aligned with the Navy's need to maintain its land disposal capability while minimizing cost and manpower requirements. The results of this effort will assist Engineering Field Division (EFD) and Public Works (PW) personnel in characterizing the problems facing their facilities with regards to continued on-base disposal operations, identifying areas of concern in the development of new facilities in wetland and non-wetland areas, and to provide information on the methods and cost of upgrading and/or developing new and existing sites to comply with new regulations.

This effort, under the guidance of CEL, was performed by JRB Associates and EMCON Associates. The work was divided into three major tasks. The first task was the identification and definition of potential environmental and operational problems in land disposal of solid waste aboard Navy installations that relate to the implementation of the Federal landfill classification criteria (40 CFR 257). The work involved the compilation of existing information on Navy disposal sites as well as 15 field visits to gather specific, missing data. The second task was to identify and assess Navy application of technological alternatives for resolving the potential problem areas. This effort involved a review of remedial technological alternatives and associated costs for upgrading disposal sites in accordance with the Federal criteria. The third task was to evaluate the siting and operational procedures required for the development of future Navy solid waste disposal sites. This was accomplished by utilizing the information gathered from the 15 field visits to active on-base disposal sites plus an additional three visits to Naval bases situated in wetlands environments (but not necessarily operating landfills). The document prepared from this effort was divided into three volumes.

Volume 1 identified the "Criteria for Classification of Solid Waste Disposal Facilities and Practices," 40 CFR 257. The eight categories addressed in the Federal regulation were: floodplains, endangered species, surface water, groundwater, disease, air, safety and land spreading. In order to assist field personnel in assessing these categories and identifying areas of possible noncompliance, a "decision tree" flow diagram was developed for each category. The decision tree consists of a series of questions that, when answered about a specific site, determine if remedial action is required. The last segment of this volume identifies the siting and operational requirements for constructing new solid waste disposal sites in wetlands and other environmentally sensitive locations.

Volume 2 of this document is intended to provide guidance to landfill designers and operators in selecting the most cost effective remedial technology based on an assessment of site specific conditions identified using the decision tree guide provided in Volume 1. This volume presents available remedial technologies, as well as avante-garde concepts that may be utilized in bringing Navy solid waste disposal sites into compliance with Federal criteria. A summation of these technologies and their associated costs are presented in Table 1-1.

Volume 3 of this document summarizes the observations and findings of the study, identifies the potential areas of criteria noncompliance within the Navy, and presents an estimate of the economic impact of upgrading the 39 known Navy disposal sites. The results of this effort are summarized in Chapter 2.

CRITERION	REMEDIAL ACTION ALTERNATIVES	UNIT CAPITAL COST*	AVERAGE O&M COSTS (% of Capital Cost)
Floodplains	Perimeter Berms	\$230 - 350/yd	3
	Floodwalls	350 - 600/yd	4
	Control of Backwater Flow	7K - 30K total	9
Endangered Species	Protecting Endangered Species	Site Specific	Site Specific
	Selective Landfilling	Site Specific	Site Specific
	Mitigation Land	Site Specific	Site Specific
Surface Water	Ditches, Diversions, Waterways	15 - 20/yd	6
	Terraces and Benches	5 - 9/yd	5
	Chutes and Downdrains	90/yd	5
	Drainage System	40 - 630/yd	4
	Grading and Revegetation	3 - 8/yd ²	3
	Surface Capping	10 - 30/yd ²	5
	Sedimentation Ponds	8K - 11K/acre ft	4
	Liners	27K - 70K/acre	5

* cost without engineering or contingency costs.
 K = \$1000

TABLE 1-1 Alternative Landfill Technologies and Associated Costs

CRITERION	REMEDIATION ACTION ALTERNATIVES	UNIT CAPITAL COST*	AVERAGE O&M COSTS (% of Capital Cost)
Groundwater	Trenches	\$300 - 5K/yd	2
	Grouting	6K - 11K/ yd	2
	Subsurface Drains	530 - 700/ yd	
	Extraction Wells	25 - 50/vert. ft	6
	Leachate Collection	25 - 30/ yd	4
	Leachate Treatment	20K - 500K total	15
	Leachate Attenuation	230 - 325/ yd	6
	Groundwater Monitoring	75/vert. yd +3K/ well	\$400/ sample + 1% /well
	Sewage Sludge -	Site Specific	Site Specific
	Septic Tank Pumping	Site Specific	Site Specific
Disease	Controlling Vectors	Site Specific	Site Specific
	Controlling Rodents	Site Specific	Site Specific
	Controlling Mosquitos	Site Specific	Site Specific
	Controlling Health Hazards	Site Specific	Site Specific
	Controlling Fires	Site Specific	Site Specific
Air	Controlling Dust	Site Specific	Site Specific
	Gases - Well Probes	4.2K - 4.7K/ acre	\$700/ sample + 1% /well
	Vents	400 - 600	9
	Fires	Site Specific	Site Specific
Safety	Birds	32K/ acre	4
	Access	30/ yd + 2.5K	4

2.0 SUMMARY

2.1 Active Navy Disposal Sites

This section presents the findings of the study based upon the 15 active on-base landfills visited. Selection of these facilities was based upon the following criteria:

- selected disposal sites must be representative of all Navy sites
- geographical areas (North, South and Central regions of the United States) must be represented
- some sites should be located within the Standard Metropolitan Statistical Area where the Navy has been designated lead agency
- operating life of the site should be greater than 3 years

From the possible active on-base landfills, CEL selected the following facilities:

Naval Base, Great Lakes, IL
Naval Weapons Support Center, Crane, IN
Marine Corps Air Station, Quantico, VA
Naval Ordnance Station, Indian Head, MD
NAS Patuxent River, MD
Marine Corps Base, Camp LeJeune, NC
NAS, Whiting Field, FL
NAS, Mayport, FL
NAS, Ocean, Virginia Beach, VA
NAS, Moffett Field, CA
Mare Island, Naval Shipyard, Vallejo, CA
Marine Corps Base, Camp Pendleton, CA
NAS, Miramar, San Diego, CA
NAS, Fallon, NV
NAS, Oak Harbor, WA

2.1.1 Findings

The general observations and findings from the sites visited are as follows:

- Most Navy disposal sites were in good condition and would require only a minor amount of upgrading to comply with RCRA Section 4004.
- A number of the sites were receiving wastes which are on EPA's hazardous waste list; most notably asbestos. Although the Navy has a need to dispose of large quantities of asbestos, this waste material needs to be either taken off site by a certified disposal operator or the Navy needs to apply for individual State permits for disposal of this waste. This has been done on at least one base, and therefore, may be the preferred course of action.
- Most of the disposal operations are small, averaging less than 50 tons per day of solid waste.
- A few sites had waste quantities in excess of 100 TPD, composed mostly of paper and putrescibles. These sites would be likely candidates for alternate disposal technology when costs for upgrading current landfill sites and developing new landfill sites to comply with the criteria are considered.
- The majority (11) of the sites may have a potential problem meeting the groundwater criteria. This is especially true in areas with medium to high soil permeability and high water table, such as the East coast. Groundwater compliance may prove to be the most serious problem facing these landfills. Monitoring programs would be most useful in accessing any adverse impacts these sites may have on the underlying aquifers.
- A potential problem area common to a number of Naval landfills is compliance with the safety criteria, especially site access and gas generation. Remedial actions would require enclosure of the facilities and establishment of gas monitoring programs, respectively.

2.2 Future Navy Solid Waste Disposal Sites

This section summarizes the findings relative to the Federal requirements concerning the siting of new solid waste disposal facilities at Naval installations. This task required visits to three additional Naval bases situated in a wetlands environment.

The bases selected were:

Naval Amphibious Base, Little Creek, Norfolk, VA
Naval Shipyard, Norfolk, VA
Naval Air Station, New Orleans, LA

2.2.1 Findings

Non-Wetland Areas. Based on the information obtained from the 15 active on-base disposal sites and a review of the Federal criteria it was found that the Navy will generally have to do the following to locate a landfill in a non-wetland area:

- groundwater monitoring
- obtain NPDES and Dredge and Fill Permits (as required)
- install leachate collection and treatment systems
- ensure the isolation of the refuse from groundwater

Construction of a new landfill in a non-wetland area will increase disposal costs by approximately 50% to an estimated \$12.00 per ton for disposal.

Wetland Area. From the information gathered at the 3 Naval bases located in a wetlands environment, the following items for constructing a landfill will have to be considered:

- depression of the watertable
- detailed groundwater monitoring
- levees
- leachate treatment and collection
- hydrologic diversion systems
- NPDES and Dredge and Fill Permits

The fact that many Naval installations are located in areas of the U.S. that are typified by wetlands topography presents the Navy with the unique and more difficult problem of disposing of solid waste in an environmentally suitable area. In order to comply with both the Executive and DOD orders on wetland protection, the Navy must evaluate all potential alternatives for solid waste disposal from both the economic and environmental perspectives. Should a Naval activity decide to pursue land-disposal in a wetlands it must be prepared to face a long, difficult, and expensive permitting process and possible legal action. Upon completion of this phase of the development process, the Naval activity must be prepared for the considerable expense of engineering and constructing the actual site. The technologies commonly associated with abating the environmental problems posed by construction of a landfill in a wetland are expensive to design and implement. A conservative estimate for disposal of solid waste in a "wetlands landfill" is \$30.00 per ton.

2.3 Economic Impact of Active Disposal Sites

The remedial alternatives and associated costs identified by the 15 field visits permitted CEL to estimate an overall economic assessment for all 39 disposal sites. This was accomplished by categorizing the remaining 24 disposal sites according to geographical location, and thus identify

certain physical and environmental characteristics. Those nonsurveyed sites situated in the same geographic regions as the surveyed sites were assumed to have similar problems in meeting the Federal criteria. Table 2-1 shows the economic results of this analysis. The estimated capital costs for constructing the recommended remedial alternatives is approximately \$4.7 million, with annual operation and maintenance (O&M) of \$330,000.

<u>CRITERIA</u>	Expenditures For Upgrading 39 Disposal Sites	
	Total Capital Costs *	Total O&M Costs *
Floodplains	600K	14K
Endangered Species	-	-
Surface Water	1905K	60K
Groundwater	546K	185K
Disease	-	-
Air	-	-
Safety		
Gas	25K	35K
Fire	-	-
Bird Hazard	-	-
Access	663K	36K
total construction	3739K	
9% engineering	<u>337K</u>	
	4076K	
15% contingency	<u>611K</u>	
	4687K	330K
TOTAL: Capital Costs	4687K	
O & M Costs	330K	

* Costs are based on 1979 figures.

(-) No expenditures required.

K \$1000

Table 2-1 Criteria Compliance Expenditures for Upgrading
Active Navy Disposal Sites

3.0 RECOMMENDATIONS AND CONCLUSIONS

3.1 Active Disposal Sites

The RCRA and subsequent 40 CFR 257 criteria requires the disposal of solid waste to be in a manner that minimizes the possibility of adverse effects on health or the environment. From the information provided by the contractor it appears that the 39 active disposal sites owned by the Navy will require minor upgrading (in most cases) to comply with these regulations. The most serious problem facing these landfills will be compliance with the groundwater criteria. It is recommended that monitoring wells and periodic water sampling procedures be established at each disposal site to assess any potential adverse effects.

3.2 Future Disposal Sites

The fact that many Navy installations are located in areas of the U.S. that are typified by wetlands topography presents the Navy with the unique and more difficult problem of disposing of solid waste in an environmentally suitable area. Should the Navy decide to pursue land disposal in a wetlands it must be prepared to face a long, difficult, and expensive permitting process and possible legal action. At this time it is not recommended that wetland environments be considered potential alternatives for disposal of solid waste. Also, the construction of a new landfill in a non-wetland area should be given serious consideration when future disposal alternatives are being evaluated.

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1.0 INTRODUCTION

The RCRA and subsequent 40 CFR 257 criteria requires the disposal of solid waste to be in a manner that minimizes the possibility of adverse effects on health or the environment. The Navy, like any other Federal agency, disposing of solid waste in landfills is subject to these regulations, including the EPA mandated "Open Dump Inventory." This inventory will identify disposal sites not meeting the Federal criteria, and require these sites to be either closed or upgraded according to a state-established compliance schedule.

The disposal of solid waste at on-base Naval landfills is generally the least expensive means of disposal available to the Navy at the present time. If the Navy wishes to continue these on-base operations, it is necessary to identify the steps and remedial actions that must be taken to keep these sites in compliance with the above mentioned regulations.

The subsequent chapters of Volume 3 will summarize the observations and findings of the contractor, identify potential areas of criteria noncompliance and finally present an economic analyses for upgrading all Naval disposal sites.

1.1 Background

In fiscal years 1977 and 1978 the Chief of Naval Operations, at the request of the EPA, implemented an assessment of Naval land-disposal operations. The data compiled from the resulting surveys by the Civil Engineering Laboratory (CEL) and the Navy Environmental Support Office (NESO) are presented in Tables 1-1 to 1-6. The information indicated that past Navy practices dictated that solid waste be disposed of by the most economical methods, usually in remote areas unserviceable for most shore-based fleet support functions, with environmental consideration being subordinate to that of the solid waste disposal activities primary mission.

The information from these preliminary studies indicated the need for more comprehensive data, especially in the area on noncompliance with 40 CFR 257. To allow forecasts concerning the cost of upgrading the technologies available and the need for additional research to improve the cost effectiveness of remedial actions. To obtain the additional information CEL contacted JRB Associates to perform an in-depth assessment of Navy disposal sites. This effort was performed during fiscal year 1979, which comprised three major tasks. The first task was to identify and define potential environmental and operational problems in land disposal of solid waste aboard Navy installations. This work

Table 1-1 Types of Navy Disposal Sites as
Reported for CEL Survey, 1978

Type of Disposal	Reported in Survey	Percentage of Total Reported
Active On-base Disposal Sites	45	33
Inactive Disposal Sites	26	19
Off-base Disposal	63	46
Total		137

Table 1-2 Characteristics of Reported Solid Waste
Disposal Sites Used by Navy

[Source: NACWIS data base, July 1978]

Location of Site	Sites		Solid Waste	
	Number	Percentage of Total Number	Volume (TPD ₅)	Percentage of Total Volume
On-Base Sanitary Landfills and Related Activities	56	39	1,056	42
On-Base Open Dumps	5	3	149	6
Off-Base Sanitary Landfills, Private Landfills, Related Activities	82	57	1,295	52
Total	143	100	2,500	100

Table 1-3 Distribution of Navy Solid Waste Facilities by Size

[Source: NACWIS data base, July 1978]

Size of Facility (TPD ₅)	Number of Facilities	Percentage of Total Number
< 15	70	57
16-40	39	32
41-80	11	9
> 80	3	2
Total	123	100

Table 1-4 Types of Navy Disposal Operations as
Reported in CEL Survey, 1978^a

Type of Operation	Percentage of Total Reported
State Permits	2%
Cut-and-Fill	8%
Trench Method	3%
Slope Method	29%
Daily Compaction and Cover	Unknown
<20 TPD	81%

^aCost averaged \$6 to \$8/ton.

Table 1-5 Remaining Site Life for Selected Navy Solid Waste Activities

[Source: NACWIS data base, July 1978]

Remaining Site Life (yr)	Number of Sites	Percentage of Total Number
<3	14	37
3-7	3	8
8-15	12	31
>15	9	24
Total	38	100

Table 1-6 Types of Navy Environmental Controls as Reported in CEL Survey, 1978

Type	
Leachate Control	Unknown
Leachate Monitoring	6%
Gas Monitoring	3%
Gas Control	Unknown

involved the compilation of existing information on Navy disposal sites as well as 15 field visits to gather specific information concerning the upgrading requirements faced by the Navy. The second task was to identify and assess Navy application of technological alternatives and associated costs for resolving these potential problem areas. This effort involved a review of current methods, as well as those being developed under research sponsored by the EPA and other organizations. The third task was to evaluate the siting and operational procedures required for the development of future Navy solid waste disposal sites. This was accomplished by utilizing the information gathered from the 15 field visits for the active on-base disposal sites and an additional 3 visits to Naval bases situated in a wetlands environment (but not necessarily operating a landfill).

2.0 SUMMARY

2.1 Active Navy Disposal Sites

This section presents the findings of the contractor based upon the fifteen active on-base landfills. Selection of these facilities was based upon a number of facts:

- o geographical area (North, South and Central regions of the United States)
- o selected disposal sites must be representative of all Navy sites
- o some sites should be located within the Standard Metropolitan Statistical Area where the Navy has been designated lead agency
- o operating life of the site should be greater than 3 years.

From the 45 possible active on-base landfills, CEL selected the following facilities:

Naval Base, Great Lakes, IL
Naval Weapons Support Center, Crane, IN
Marine Corps Air Station, Quantico, VA
Naval Ordnance Station, Indian Head, MD
NAS Patuxent River, MD
Marine Corps Base, Camp LeJeune, NC
NAS, Whiting Field, FL
NAS, Mayport, FL
NAS, Oceana, Virginia Beach, VA
NAS, Moffett Field, CA
Mare Island, Naval Shipyard, Vallejo, CA
Marine Corp Base, Camp Pendleton, CA
NAS, Miramar, San Diego, CA
NAS, Fallon, NV
NAS, Oak Harbor, WA

2.1.1 Findings

The general observations and findings reported by the contractor from the 15 disposal sites visited are as follows:

- o Most Navy disposal sites were in good condition and would require only a minor amount of upgrading to comply with RCRA Section 4004.

- o A number of the sites are receiving hazardous wastes which are on EPA's hazardous waste list; most notably asbestos. Although the Navy has a need to dispose of large quantities of asbestos, this waste material needs to be either taken off site by a certified disposal operator or the Navy needs to apply for individual State permits for disposal of this waste. This has been done on at least one base, and, therefore, may be the preferred course of action.
- o Most of the disposal operations are small, averaging less than 50 tons per day of solid waste.
- o A few sites had waste quantities in excess of 100 TPD, composed mostly of paper and putrescibles. These sites would be likely candidates for alternate disposal technology when costs for upgrading current landfill sites and developing new landfill sites to comply with the criteria are considered.

Table 2-1 identifies the areas of possible noncompliance with the Federal criteria for the 15 Naval landfills. The disposal sites on this table are divided into three regions (i.e., West, East and Central United States), with further classification according to physical variances within each region. Figure 2-1 defines the boundaries of these physical variances while Table 2-2 identifies their unique characteristics.

The information obtained from these landfill visits revealed that 11 of the sites may have a potential problem meeting the groundwater criteria. This is especially true in areas with medium to high soil permeability and high water table, such as the East coast. Groundwater compliance may prove to be the most serious problem facing these landfills. Monitoring programs would be most useful in assessing any adverse impacts these sites may have on the underlying aquifers.

A second potential problem area common to a number of Naval landfills is compliance with the safety criteria, especially site access and gas generation. Remedial actions would require enclosure of the facilities and establishment of gas monitoring programs, respectively.

2.2 Future Navy Solid Waste Disposal Sites

This section summarizes the findings relative to the Federal requirements for new solid waste disposal facilities at Naval installations. This task required visits to three additional Naval bases situated in a wetlands environment.

The bases selected were:

Amphibious Base Little Creek, Norfolk, VA
 Naval Shipyard, Norfolk, VA
 NAS, New Orleans, LA

CRITERIA	NAVY DISPOSAL SITE LOCATIONS IN CONTINENTAL UNITED STATES														
	WEST			EAST			Subtropical Hot Continental			CENTRAL					
	Marine	Mediterranean	Desert Steppe								Hot	Continental Prairie			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Floodplains							*								
Endangered Species							*	*					*		
Surface Water	*	*	*	*	*	*	*	*	*	*	*	*			
Groundwater	*	*	*	*	*	*	*	*	*	*	*	*			
Disease															
Air															
Safety							*		*	*					
Gas															
Fire															
Bird Hazard															
Access															

* Indicates areas of possible noncompliance with Federal criteria

Table 2-1 Suspected Areas of Criteria Noncompliance for the
15 Navy Disposal Sites Visited by the Contractor

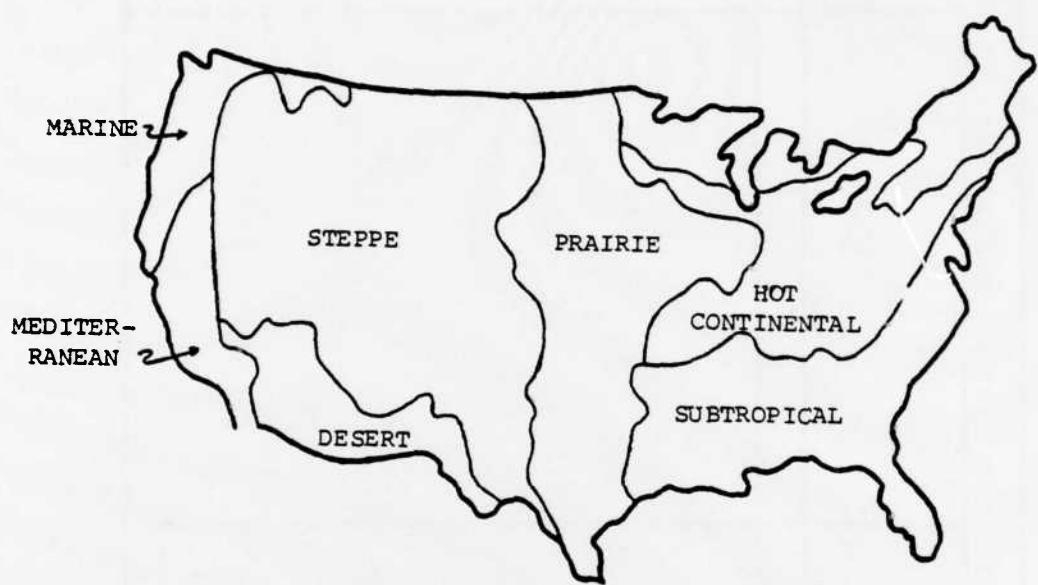


Figure 2-1 Regional Subdivisions

Physical Parameters	Geographic Regions in Continental United States				Central Prairies
	West	Mediterranean	Desert Steppe	Subtropical Hot Continental	
Soil Type	Silty Clays	Silty-Sandy Cobble Mix.	Sandy	Sandy-Clay	Clayey-Loam
Permeability	Low	Medium-High	High	Medium-High	Low-Medium
Depth to Groundwater (feet)	> 15	> 10	0-10	0-15	> 15
Rainfall (inches)	14-19	10-15	~5	45-60	> 40

Table 2-2 Regional Physical Characteristics

2.2.1 Findings

Non-Wetland Areas Based on the information obtained from the 15 active on-base disposal sites and a review of the Federal criteria it was found that the Navy will generally have to do the following to locate a landfill in a non-wetland area:

- o groundwater monitoring;
- o obtain NPDES and Dredge and Fill Permits (as required);
- o install leachate collection and treatment systems; and
- o ensure the isolation of the refuse from groundwater.

Construction of a new landfill in a non-wetland area will increase disposal costs by approximately 50% to an estimated \$12.00 per ton for disposal.

Wetland Area From the information gathered at the 3 Naval bases located in a wetlands environment, the following items for constructing a landfill will have to be considered:

- o depression of the watertable;
- o detailed groundwater monitoring;
- o levees;
- o leachate treatment and collection;
- o hydrologic diversion systems; and
- o NPDES and Dredge and Fill Permits.

The fact that many Naval installations are located in areas of the U. S. that are typified by wetlands topography presents the Navy with the unique and more difficult problem of disposing of solid waste in an environmentally suitable area. In order to comply with both the Executive and DOD orders on wetland protection, the Navy must evaluate all potential alternatives for solid waste disposal from both the economic and environmental perspectives. Should a Naval activity decide to pursue land-disposal in a wetlands it must be prepared to face a long, difficult, and expensive permitting process and possible legal action. Upon completion of this phase of the development process, the Naval activity must be prepared for the considerable expense of engineering and constructing the actual site. The technologies commonly associated with abating the environmental problems posed by construction of a landfill in a wetland are extremely expensive to design and implement. A conservative estimate for disposal of solid waste in a "wetlands landfill" is \$30.00 per ton.

3.0 IMPACT OF CRITERIA ON NAVY

3.1 Current Landfill Status

Presently the Navy operates 39 active on-base disposal sites, which is six less than that reported in the 1978 CEL survey (see Table 1-1). The main reason for these closures were due to exhaustion of fill capacity at these sites, although in one instance a site was forced to close because of suspected groundwater contamination.

Table 2-1, as discussed previously, identified the location and areas of criteria noncompliance for the 15 landfills visited by the contractor. Table 3-1, similarly, shows the location of the 24 remaining active disposal sites not assessed by the contractor and their areas of suspected noncompliance with the criteria. Determination of criteria noncompliance for these 24 disposal sites was accomplished by utilizing the information acquired from the 15 surveyed landfills. For example, Table 2-1 shows that 6 of the 7 (or 86%) surveyed landfills in the East (Subtropical-Hot Continental) Region are in possible violation of the groundwater criteria. From this statistic a projection was made that 86% or 9 to 10 of the 11 nonsurveyed disposal sites in the East (Subtropical-Hot Continental) Region, as shown on Table 3-1, are potentially in violation of the groundwater criteria. This procedure was adopted for each of the remaining criteria.

3.2 Economic Factors

Tables 3-2 and 3-3 present a summary of recommended capital, and operation and maintenance (O&M) expenditures for compliance with the Federal criteria. The cost figures on both tables appear in two columns, designated (1) and (2), for each geographic regional subdivision. Column (1) presents the total estimated expenditures for upgrading surveyed disposal sites found in violation of the respective criteria. For example, Table 3-2 shows that it would require a total capital investment of \$47,000 to establish monitoring programs at the six disposal sites suspected of violating the groundwater criteria in the East (Subtropical-Hot Continental) Region. The annual O&M expenses at these six sites would total \$35,000, as shown on Table 3-3.

Column (2) of Tables 3-2 and 3-3 identify the criteria compliance costs for those disposal sites not visited by the contractor in each geographic region. The derivation of these cost estimates were based upon information supplied by the contractor from their 15 disposal site assessments. An example of this methodology is presented below.

For example, a \$47,000 capital investment would be required to establish groundwater monitoring programs at the six contractor surveyed disposal sites, with an average cost of approximately \$8,000 per site.

CRITERIA	NAVY DISPOSAL SITE LOCATIONS IN CONTINENTAL UNITED STATES				
	WEST	Mediterranean	Desert Steppe	Subtropical Hot Cont.	CENTRAL Hot Continental Prairie
Marine	2	4	1	11	6
Floodplains	-	-	-	4	-
Endangered Species	-	-	-	-	-
Surface Water	-	-	-	3	3
Groundwater	1	2	-	10	3
Disease	-	-	-	-	-
Air	-	-	-	-	-
Safety					
Gas	1	2	-	4	-
Fire	-	-	-	-	-
Bird Hazard	-	-	-	-	-
Access	-	-	-	5	3

(-) Indicates areas of compliance with the criteria

Table 3-1 Suspected Areas of Criteria Noncompliance for the 24 Navy Disposal Sites Not Visited by the Contractor

$$K = \$1000$$

(1) Disposal sites visited by contractor.

(2) Disposal sites not visited by contractor.

- No expenditures required.

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Table 3-2: Total Capital Upgrading Costs for the 39 Navy Disposal Sites

CRITERIA	WEST		Mediterranean		Desert Steppe		EAST		Subtropical		Hot Continental		CENTRAL		Total \$
	Marine	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Floodplains	-	-	-	-	-	-	-	7K	7K	-	-	-	-	14K	-
Endangered Species	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Surface Water	-	-	-	-	-	-	-	16K	24K	5K	15K	60K	15K	60K	15K
Groundwater	14K	10K	6K	12K	8K	8K	35K	60K	8K	24K	24K	185K	24K	185K	24K
Disease	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Air	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Safety	4K	4K	3K	6K	-	-	12K	16K	-	-	-	-	35K	-	35K
Gas	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fire	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bird Hazard	-	-	-	-	-	-	-	9K	15K	3K	9K	36K	9K	36K	9K
Access	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OPERATION AND MAINTENANCE COSTS:															330K

K = \$1000

- (1) Disposal sites visited by contractor.
- (2) Disposal sites not visited by contractor.
- No expenditures required.

Table 3-3 Operation and Maintenance Costs for Remedial Alternatives at the 39 Navy Disposal Sites

This cost data along with the previously identified 9 to 10 disposal sites in the East (Subtropical-Hot Continental) Region, which were not visited by the contractor, that are suspected of violating the groundwater criteria were utilized in deriving a cost estimate. This estimate was made by multiplying the average cost per site (8,000) by the number of sites (assume 10) giving a total capital investment of \$80,000. This same procedure was adopted for determination of O&M costs. The total capital cost, based on 1979 cost figures, for upgrading all of the 39 Naval on-base disposal sites would be approximately \$4.7 million, with annual O&M expenditures of \$330,000.

4.0 CONCLUSIONS AND RECOMMENDATIONS

The RCRA and subsequent 40 CFR 257 criteria requires the disposal of solid waste to be in a manner that minimizes the possibility of adverse effects on health or the environment. From the information provided by the contractor it appears that the 39 active disposal sites owned by the Navy will require minor upgrading (in most cases) to comply with these regulations. The most serious problem facing these landfills will be compliance with the groundwater criteria. It is recommended that monitoring wells and periodic water sampling procedures be established at each disposal site to assess any potential adverse effects.

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